INFLUENCE OF ANTHROPOMETRIC MEASURES ON THROWING POWER

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Abstract

The main purpose of this research was to determine if the anthropometric measures have a significant impact on throwing power of top level junior handball players. The correlation coefficients and the stepwise linear regression analyses were used to determine the relations between the anthropometric measures and the throwing power tests. The predictor group consisted of 11 variables of anthropometric measures and the criterion variables were the results scored in 4 different throwing power tests. Significant relations were determined between the anthropometric measures and throws from 4 meters from a sitting position (ρ^2=0.63, p<0.02), standing throw from 6 meters (ρ^2=0.81, p<0.01), and run up three step jump shot from 9 meters (ρ^2=0.80, p<0.01).

Key words: *handball, top level junior players, anthropometric measures, throwing power*

Introduction

If a handball match is closely inspected, it is obvious that key movements in the handball matches are the ones regarding the manipulation of the ball especially throwing the ball to a team player or towards the opponent's goal. There are three factors that are important for any handball throw: the throwing technique, the timing of the consecutive movement of body segments, and the level of motor abilities (Gorostiaga et al., 2005). The most important abilities behind throwing movements are mainly power, coordination and accuracy (Gorostiaga et al., 2005,). The level of power and precision used during a throw depends on the objective of such action. There have been studies regarding the isokinetic tests and such findings should be considered with great care due to the fact that the tests do not reflect natural movements, or more precisely the total kinetic chain created with the handball throw is excluded in such tests (Baiyos et al., 2001; Gorostiaga et al., 2005). Although special care must be contributed to the development of technical and tactical skills, to act accordingly in any given in-game situation a handball player must also be highly trained in terms of strength, power (jumping, running, throwing), both anaerobic and aerobic endurance, agility and quickness (Gorostiaga et al., 1999; Gorostiaga et al., 2005; Srhoj et al., 2006). The development of throwing power is an important issue regarding the construction of training plan and program during the pre-season and in-season periods.

A significant amount of studies has been conducted regarding the effects of different training programs aimed to increase throwing power in handball (Barata, 1992; Gorostiaga et al., 1997; Van Den Tillaar, 2004; Wagner, & Müller, 2008) and effects of an entire season on the development of throwing power (Gorostiaga et al., 2006). The handball jump shot and the ground shot are the two the most commonly studied movement patterns of the handball game. Kinematical analyses of the jump shot and the ground shot revealed that the movement of the individual body parts in the right way, allow the built velocity from individual segments of the body to transfer to the ball, thus allowing the development of maximal velocity to achieve top speed throws (Zahalka et al., 1997; Taborsky et al., 1999; Pori et al., 2005, Šibila et al., 2005; Wagner & Müller, 2008). In handball one of the criterions for selection are the anthropometric measures of players and the second probably more important is the level of skills (Srhoj et al., 2006). The main purpose of this study was to determine whether the anthropometric measures have significant impact on throwing power of top level junior handball players.

Methods

Participants. The participants were 18 top level junior Croatian National team handball players (Mean ± SD; age = 18 ± 1 years, handball experience = 7 ± 2 years, height = 187.88 ± 6.25, weight = 87.13 ± 11.54, Body fat % = 10.01 ± 2.97, BMI = 24.43 ± 2.41 kgm^{-2}) who volunteered to participate in this study. All experimental procedures were approved by the Ethics Committee of the Faculty of Kinesiology, University of Zagreb. *Anthropometric measures.* The measures related to arm dimensions were acquired by measuring the dominant arm and the measure related to the leg dimension was taken from the front/take off leg. Heights (H), arm lengths (AL), arm spans (AS), shoulder widths (SW), leg lengths (LL) have been measured with an anthropometer (Harpenden anthropometer) to the nearest 0.5 cm. To measure the hand span (HS) was measured as described in a previous study (Visnapuu, & Jürimäe, 2007). The measurements were taken by one examiner for all participants***.*** Body mass (BM) was obtained to the nearest 0.1 kg using balance beam scale (Seca, German engineering and technology).

Body mass index (BMI) ($kg \cdot m^{-2}$) was calculated for each subject. Body fat was calculated by using seven skinfold thickness (Jackson & Pollock, 1978.). Body volume measures included chest girth (CG), upper arm girth (UAG), forearm girth (FG), and upper leg girth (ULG). *Throwing power tests.* The four tests used were: throw from 4 meters from a sitting position (R4M), standing throw from 6 meters (R6M), three step run up throw from 9 meters (R9MRG) and run up three step jump shot from 9 meters (R9MJS). The detailed instructions about the testing protocols and procedures regarding four throwing power tests can be found in a previous study (Vuleta jr. et al., 2010). *Statistical Analyses* The Statistica 7.0 for Windows statistical package (Statsoft Inc., Tulsa, Oklahoma) was used to process and report the data. The measures of central tendency and variability are presented as Mean ± SD, Min, Max and Range. Pearson correlation coefficients (r) were used to assess the relationship between the selected variables with a significance level of p, 0.05. The coefficients of multiple correlations (ρ) and the squared coefficients of multiple correlations (ρ^2) were used as a measure to determine the relationship between the predictor and criterion variables. The relationships of each statistically significant variable to the set criterion in the regression models were presented by the standardized regression coefficients (β) and the regression coefficients (B). In addition, the standard errors of standardized regression coefficients (SE_β) and the standard errors of regression coefficients (SE_B) were presented for each statistically significant predictor variable.

Results

The reliability coefficients were very high with all four tests. Detailed information on the reliability and the validity of the four tests used for the assessment of throwing power can be found in a previous study (Vuleta jr. et al., 2010). All variables had normally distributed data.

Table 1. Descriptive statistics of anthropometric measures and throwing power tests

	X ± SD	SE	Min	Max	Range
H (cm)	187.88 ± 6.25	1.47	177.30	197.00	19.70
BM (kg)	87.13 ± 11.54	2.72	66.87	110.76	43.89
AL (cm)	82.98 ± 3.55	0.84	76.80	89.50	12.70
AS (cm)	190.15 ± 7.25	1.71	176.5	202.00	25.50
SW (cm)	41.03 ± 2.00	0.47	37.60	44.60	7.00
HS (cm)	23.54 ± 2.16	0.51	21.00	31.40	10.40
LL (cm)	107,53 ± 3,76	0.86	102.00	116.30	14.30
CG (cm)	99.46 ± 5.58	1.31	90.40	114.50	24.10
UAG (cm)	35.69 ± 1.92	0.45	32.90	39.20	6.30
FG (cm)	30.41 ± 1.17	0.28	27.70	32.20	4.50
ULG (cm)	62.39 ± 4.96	1.17	53.10	72.40	19.30
R4M ($km \cdot h^{-1}$)	58.96 ± 3.61	0.85	52.70	65.33	12.63
R6M ($km \cdot h^{-1}$)	85.36 ± 6.87	1.62	66.03	95.37	29.33
R9MRG ($km \cdot h^{-1}$)	92.61 ± 5.31	1.25	81.70	101.63	19.93
R9MJS ($km \cdot h^{-1}$)	90.06 ± 4.31	1.02	82.13	97.97	15.83

Statistically significant correlations were found between the variables: R4M and R6M (r = 0.67, p < 0.05), R4M and R9MRG (r = 0.71, p < 0.05), R4M and H (r = 0.51, p < 0.05), R4M and CG (r = 0.52, p < 0.05), R4M and AS (r = 0.56, p < 0.05), R6M and R9MRG (r = 0.82, p < 0.05), R6M and R9MJS (r = 0.84, p < 0.05), R6M and Height (r = 0.54, p < 0.05), R6M and BM (r = 0.49, p < 0.05), R6M and AL (r = 0.73, p < 0.05), R6M and AS (r = 0.77, p < 0.05), R6M and LL (0.62, p < 0.05), R9MRG and R9MJS (r = 0.72, p < 0.05), R9MJS and AL (r = 0.56, p < 0.05), R9MJS and AS (0.50, p < 0.05), R9MJS and HS (0.59, p < 0.05), R9MJS and LL (0.52, p < 0.05), H and BM (r = 0.67, p < 0.05), H and AL (r = 0.79, p < 0.05), H and AS (r = 0.83, p < 0.05), H and LL (r = 0.84, p < 0.05), H and FG (r = 0.53, p < 0.05), BM and AL (r = 0.53, p < 0.05), BM and AS (r = 0.67, p < 0.05), BM and CG (r = 0.84, p < 0.05), BM and UAG (r = 0.66, p < 0.05), BM and FG (r = 0.85, p < 0.05), BM and LL (r = 0.48, p < 0.05), BM and ULG (r = 0.90, p < 0.05), AL and AS (r = 0.93, p < 0.05), AL and LL (r = 0.89, p < 0.05), AS and FG (r = 0.53, p < 0.05), AS and LL (r = 0.83, p < 0.05), CG and UAG (r = 0.71, p < 0.05), CG and FG (r = 0.79, p < 0.05), CG and ULG (r = 0.78, p < 0.05), UAG and FG (r = 0.62, p < 0.05), UAG and ULG (r = 0.62, p < 0.05), FG and ULG (r = 0.83, p < 0.05).

Table 2. Linear stepwise regression models summaries

Criterion	ρ	ρ^2	SE of the estimate	$F_{(7,3)}$	p
R4M	0.80	0.63	3.19	4.16	0.02
R6M	0.90	0.81	2.96	7.83	0.002
R9MRS	0.55	0.31	4.72	3.32	0.06
R9MJS	0.89	0.80	2.17	9.40	0.001

Statistically significant partial regression coefficients have been found in three of the four set regression models. In the first model where the R4M was the criterion variable set a significant partial regression coefficients have been found with the BM (β = -1.274, SE_β = 0.484, B = -0.489, SE_B = 0.186, p < 0.02), AS (β = 1.304, SE_β =0,579, B = 0.796, SE_B = 0.353, p < 0.04), and CG (β = 1.054, SE_β = 0.365, B = 0.836, SE_B = 0.289, p < 0.01) variables. In the model were the R6M was set as the criterion variable also three significant partial regression coefficients have been determined but with the variables AS (β = 1.088, SE_β = 0.298, B = 0.820, SE_B = 0.225, p < 0.004), HS (β = 0.438, SE_β = 0.156, B = 2.450, SE_B = 0.876, p < 0.02), and CG (β = 0.542, SE_β = 0.243, B = 0.530, SE_B = 0.238, p < 0.05). The third model showed no statistically significant relationship between the predictor group of variables and the set criterion variable R9MRG.

In the fourth and last model the R9MJS was set as the criterion four significant partial regression coefficients were determined with the variables HS (β = 0.436, SE_β = 0.143, B = 1.809, SE_B = 0.592, p < 0.01), AL (β =0.344, SE_β = 0.140, B = 0.393, SE_B = 0.160, p < 0.03), CG (β = 0.787, SE_β = 0.223, B = 0.571, SE_B = 0.162, p < 0.004), and ULG (β = - 0.859, SE_β = 0.224, B = - 0.700, SE_B = 0.182, p < 0.002).

Discussion and conclusion

The results of this study demonstrate that there are several important anthropometric characteristics that contribute to the throwing power of handball players. The participants of this study (Table 1.) achieved better results in the three step run up shot from the ground (R9MRG) than in the run up three step jump shot (R9MJS). This can be explained with the fact that the feet are during the ground shot longer in contact with the floor, allowing the channeling of the generated ground reaction forces throughout the kinetic chain of the whole body from the foot straight up to the ball, thus allowing the achievement of faster throws. (Baiyos et al., 2001). If the result obtained for the R6M test for junior players (Table 1.) is compared with values of senior players than it can be concluded that there is no difference between them (Baiyos et a., 2001; Gorostiaga et al., 2005; Wagner, & Müller 2008). In the R9MRG test Croatian national junior handball players achieved higher ball velocities than senior handball players (Marques et al., 2007), and in some cases lesser values than top level senior players (Gorostiaga et al., 2006), and in some cases the same or just a little higher values (Gorostiaga et al., 2005). This reveals the fact that junior handball players are indeed at the level of senior players when the throwing power is concerned. Statistically significant correlations have been found between the R4M test and the variables of height ($r = 0.51$), arm span ($r = 0.56$) and chest girth ($r = 0.52$). It was expected that such significant correlations have been found right with these measures, since the kinetic chain which passes through the complete body during a handball throw is excluded with this test, and is limited the upper regiment of the body; therefore a handball player must use his trunk and arms to generate throwing power. The significant correlation of the results of this test with the players' height suggests that a taller player will have faster throws due to the availability of a larger trajectory in the throwing movement. In addition, since the predictive group of the anthropometric variables has statistically significant impact on the results obtained from the R4M test (Table 2.), the standardized regression coefficients prove the exact same thing as the correlations, since the arm span variable ($\beta = 1.304$, $p < 0.04$) and chest girth variable ($\beta = 1.054$, $p < 0.01$) have statistically significant values. The chest girth variable is significant in this test or better said in this movement because it generates most of the throwing power, and the significance of the arm span can be explained since the movement is limited to the trunk and arms a player uses the length of both arms to generate as much angular velocity as possible to achieve top speed throws. What is also important to point out is that heavier players throw the ball with lesser velocities ($\beta = - 1.274$, $p < 0.02$). This is a consequence that is quite simple, since the movement is limited to the trunk and the arms, the larger the body, and the body parts, it will be difficult for heavier players to build up power to throw the ball fast. These results concur with the results obtained in a previous study conducted on young handball players (Visnapuu & Jürimäe, 2009) at some point in which similar significant relations have been found for the variables regarding longitudinal skeleton dimensions, the arm span and height but with outstretched hands. In the execution of the throw in the R6M test the kinetic chain is created through the whole body from the feet up, unlike the previously discussed test. In some sources the kinetic chain can also be found as a proximal-to-distal sequence and was observed in the same movement (Wagner & Müller, 2008). According to the results of this study, higher ($r = 0.54$) and heavier ($r = 0.49$) players achieved faster ball speeds, which is explained with the fact larger body mass responds to a greater muscle mass and therefore greater strength, and the strength is significantly related to throwing velocity (Marques et al., 2007). To enhance the previous statement regarding the impact of height on the velocity of the thrown ball, significant correlations of longitudinal body measures have also been found with the measures of arm span ($r = 0.77$), arm length ($r = 0.73$), and leg length ($r = 0.62$). The stepwise regression analysis also revealed a significant impact of anthropometric measures on the results in the R6M test (Table 2.). According to the results players with a longer arm span ($\beta = 1.088$, $p < 0.004$), longer hand span ($\beta = 0.438$, $p < 0.02$) and a bigger chest girth ($\beta = 0.542$, $p < 0.05$) will achieve faster ball throws which is of course expected. The importance of the arm span and chest girth can be explained in the same way as with previous test. Since the throw is executed from a standing position it does not include movement through space and creation of additional velocity for the throw on behalf of the forward movement of the complete body. In previous studies of this movement authors did not include the lower body segments in their research and stated there is a chance that the lower body segments could indeed significantly contribute to the throwing velocity. Such significant contributions have not been found in this research, and it can be stated that the lower body segments do not have a significant role in the overall velocity of the ball in this throw. Kinematical analyses of the movement used in this test in different studies revealed that the maximal angular velocity of the internal shoulder rotation and the extension of the elbow together are two main contributors to the ball velocity (Wagner & Müller, 2008), if this is taken into consideration, then the results of this study concur with such results and complete such findings due to the fact that the chest girth and arm span are statistically significant contributors to the ball velocity. A significant influence of the variable hand span on the throwing velocity points out to the fact that players with a larger hand span achieve faster ball velocities. This can be explained with the fact that during a handball throw in a standing position a firm grip of the ball gives the player more confidence and allows a better transfer of the created angular velocity from lower segments in the kinetic chain. It is also important to state that the hand is the last segment in the kinetic chain of the throwing movement and therefore plays a significant role in the precision of the thrown ball. If the movement used in the R9MRG test is observed the transfer of the achieved running speed through the joint system to the ball during the throw, allows a faster throwing speed if the movement is executed optimally. No statistically significant correlation was obtained between the anthropometric measures and the R9MRG test. The stepwise regression model showed no statistically significant relationship between the predictor group of variables and the set criterion variable R9MRG (Table 2.). The low values of relationship between the anthropometric measures and throwing velocity in this test ($\rho^2 = 0.31$) can explained as the following. The movement pattern used in this test includes much more technique than just throwing power, which could be meaning that a good technical execution (the overall transmission of power from the lower body segments to the ball) of the three step run up throw allows all players regardless their longitudinal and transversal skeletal dimensions and body voluminosity dimensions to achieve faster ball throws. If the jump shot is closely observed then it can be stated that it includes several conversions of generated speed and power. First is the run up part which consists of dribbling and standard three step run up which allows a player the create additional velocity even before the body has began its elevation. This can be labelled as the horizontal speed component which is generated through the use of a players sprinting power. Then in the take off phase the player begins his movement upwards in which the first conversion of the velocity and power occurs. From the point of motor abilities this can be labelled as the activation of the jumping power. Then a player begins a standard proximal to distal sequence in the throw phase to manifest the generated throwing power through the increase of angular velocities of all body segments which are included in the movement (Zahalka et al., 1997; Taborsky et al., 1999; Pori et al., 2005, Šibila et al., 2005). According to previous studies, 67% the ball release speed in the throw phase is the result of the summation effects from the velocity of the internal shoulder rotation of the shoulder and the elbow extension (Van Den Tillaar & Ettema, 2004, Wagner et al., 2010). The results of this study are a very good enclosure to previous studies regarding the jump shot, since a significant correlation of the dribble, run up, jump shot test (R9MJS) has been found with the measures of hand span (r = 0.59), arm length (r = 0.56), leg length (r = 0.52) and arm span (r = 0.50). It can be stated that the overall velocity of the thrown ball is in connection with the individual body segments through various phases of the jump shot. The hand span has the highest association and a positive influence on the ball velocity ($\beta = 0.436$, $p < 0.01$) which implies that during the approach, take off, flight and the throw phases in the jump shot, a larger hand span has an important role in the ball control and gives a handball player a security to achieve a faster swing, and therefore a better transfer of angular velocity of individual body segments all the way up to the ball. The measure of arm length has a significant association and a significant influence on the ball velocity ($\beta =0.344$, $p < 0.03$), which can be explained with the fact since the dominant arm was measured that the when a segment is rotated with a certain angular velocity, the longer the segment is, the higher the velocity will be developed on the distal part. The chest girth variable has a significant impact on the ball velocity in this test ($\beta = 0.787$, $p < 0.004$) but somewhat smaller than in the first sitting throw test because here a portion of the overall speed is developed through the approach and take off phases of the throw. Even in this test the chest girth variable has a significant influence which accents the importance of the muscles occupying the same region. What is interesting is that a negative impact on the ball velocity has been found with the measure of the upper leg girth ($\beta = -0.859$, $p < 0.002$). Such finding is hard to explain with certainty and needs further research. The handball throw in any modulation is a specific skill and represents the cornerstone of the handball game. The results of this study point out that the need for the further development of the muscles of the upper body region (arms, and chest) through different training modalities and to additionally improve the throwing power of junior players since it has been proven that top level junior players have a smaller chest girth than elite senior players. This study also points out to the key traits which could be observed during the selection process.

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UTJECAJ MORFOLOŠKIH MJERA NA SNAGU IZBAČAJA

Sažetak

Glavna svrha ovog istraživanja bila je utvrđivanje imaju li morfološke mjere značajan utjecaj na snagu izbačaja kod vrhunskih junior rukometaša. Korišteni su koeficijenti korelacije i stepwise linearna regresijska analiza za utvrđivanje relacija morfoloških mjera i snage izbačaja. Prediktori su bili 11 morfoloških varijabli a kriterij je bio rezultat u 4 različita testa snage. Zabilježene su značajne relacije između morfoloških mjera i bacanja sa 4 metra iz sjedenja (ρ^2=0.63, p<0.02), bacanja sa 6 metara iz stajanja (ρ^2=0.81, p<0.01), i skok-šuta u kretanju sa tri koraka sa 9 metara (ρ^2=0.80, p<0.01).

***Ključne riječi**: rukomet, vrhunski juniori, morfološke mjere, snaga izbačaja*

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